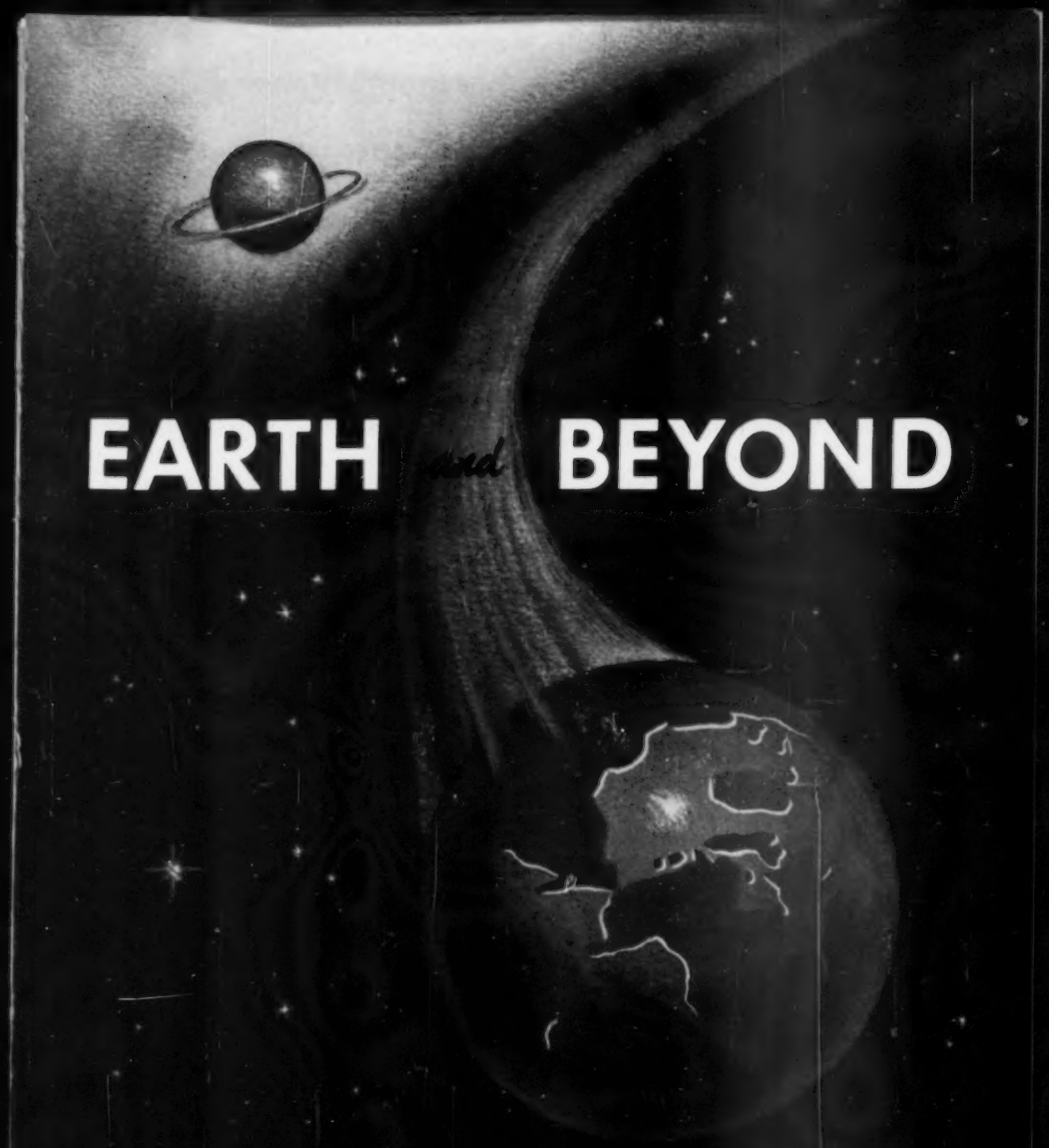

EARTH and BEYOND

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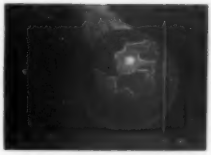


EARTH *and* BEYOND

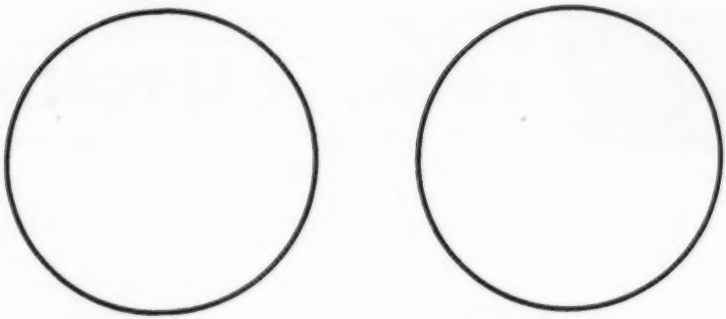
by Verne N. Rockcastle

At a regional science fair for elementary grades, there were at least a dozen models of the solar system, not one of which showed size and distance to the same scale. A quizzing of the contestants showed that they had little notion of the true relation of matter and space within our solar system. They had modeled their entries after what they had seen in books, or from the commercial models in their classrooms. Those pupils whose model earths were as large as a golf ball thought the sun would be a foot or two away. They were amazed to learn that at the scale of their models, the sun would have been about 1000 feet away, and Pluto about 8 miles. But their books and their blackboards consistently carry diagrams of the sun and all the planets in a small space. No wonder they had misconceptions about the earth and beyond!

In a popular elementary science textbook series, there are diagrams of the earth as viewed from the sun at opposite seasons of the year. The earth in the sketches has a diameter of about 8 inches, there are visible lines of latitude and longitude, and there is no land either north or south of the United States! In trying to get across one idea to the reader, the authors have inadvertently introduced three incorrect ones! If viewed from the sun, the earth would be a mere speck; there are no visible meridians nor parallels on the earth; and neither the northern nor the southern boundary of the United States is a coastline.

Another book "dedicated to elementary school children in the hope that it may aid them to gain a better understanding of life in an age of science" shows the moon passing midway between the earth and the sun in its orbit. Also, if the earth rotated on its axis as shown, eclipses would occur regularly every month, the polar ice caps would melt, and each summer one pole would burn to a crisp.

These and other fallacies about the earth and beyond must be corrected. Elementary pupils must be taught space relationships as they really exist if these pupils are to be well prepared for life in a space-conscious world. This Leaflet will help you understand some interesting and important facts about the earth and beyond, and may give you some ideas for presenting these facts to your pupils simply and accurately.



One is a circle. The other is a scale drawing of the slight bulging of the earth at the equator. Can you tell which is which?

The Earth

Size and shape

The earth is a ball about 8000 miles in diameter (closer to 7900 miles). Careful measurements have shown that the diameter from pole to pole is about 26 miles less than it is across the earth at the equator. Many books describe this condition of the earth as being *flattened* at the poles, and proceed to show the flattening by means of a drawing that makes the earth *look* flattened. On this page are two diagrams. One is a perfect circle; the other is a drawing that illustrates the shape of the earth. Can you tell which is the scale drawing? Measure across each and see which is the circle.

This great ball on which we live has an interesting surface about which we have learned a great deal, an interior about which we know little, and an atmosphere about which we are learning more daily. If the surface of the earth were smoothed of the wrinkles we call hills and mountains, water would cover us to a depth of more than a mile. With the land and water distributed as they are, the water still covers almost 71% of the earth's surface. In the northern hemisphere, water covers about 60%, and land about 40% of the earth's surface. In the southern hemisphere, water covers about 80%, and land about 20%, of the surface. The greater land masses in the northern hemisphere cause greater climatic extremes. In the southern hemisphere, the climate is more moderate because of the greater amount of water.

The earth as a whole is about 5.5 times as heavy as water, but limestone is only 2.7 times as heavy as water, and quartz is even lighter. So the interior of the earth must be composed of something much heavier than rock—perhaps iron and nickel or their compounds. In this respect, the earth is unlike some other planets whose densities are much less.

The great mass of the earth is responsible for its gravitational pull. You and the earth pulling each other holds you to the surface of the earth, as it does water, air, and soil. Gravity also keeps the moon in its orbit. Occasionally things move fast enough, however, to escape this gravitational pull. The molecules of some gases undoubtedly escaped from the earth long ago. Other, larger objects will be doing it soon—perhaps even before you read this Leaflet.

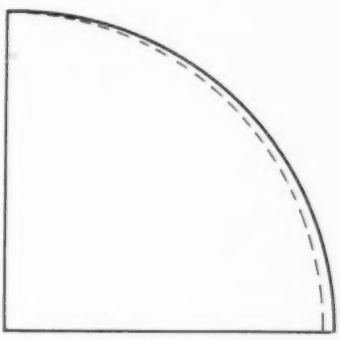
The air above the earth's surface extends up 500 or more miles. One half of it lies in the first 3½ miles above the earth's surface, however. Its great compressibility is responsible for this. Into this ocean of air project the tallest things we know of—Mt. Everest, the tallest natural object, and the Empire State Building, the tallest artificial object. Mt. Everest is 5½ miles high. On a globe a foot in diameter it would be equal to the thickness of three human hairs! The Empire State Building would project up on this globe to a height of a mere fraction of a hair's thickness. Half of the atmosphere would lie in a shell whose thickness would be about that of one hair! Try scaling these and other surface features on a globe, or on a large blackboard drawing and see if your pupils aren't amazed at the *truth!*

Much more could be written about the earth's surface. This Leaflet, though, deals more with the movements of the earth.

Movements of the Earth

Rotation

The flattening of the earth at the poles is so slight that in the drawing on page 4 it is less than the width of the ink line. Yet it has some interesting effects on the surface features of the earth and its movements. Suppose, for example, that you could view a quarter-section of the earth as shown below. The distance from the pole to the center of the earth is about 13 miles (half of 26) or 68,000 feet less than the distance from the equator to the center of the earth. Mark off on the arc (it represents the surface of the earth) the distance that the United States represents. What fraction of the distance from equator to pole does the United States occupy? Knowing this fraction, and how much farther the equator is from the center of the earth than the pole, can you determine how much farther from the



The dashed line represents the surface of a sphere. The solid line exaggerates the earth's bulge at the equator

The white dot near the center of this half-hour time-exposure is Polaris. Is it exactly at the north pole?

center of the earth is the southern edge of the United States than the northern edge? About 1/5 or more of the distance between equator and pole? Then the southern border of the United States must be about 14,000 feet (1/5 x 68,000) farther from the center of the earth than the northern border is. This means that the Mississippi River flows away from the center of the earth about 3 miles in its journey from Minnesota to the Gulf of Mexico! Or, to put it another way, it flows "uphill" nearly 3 miles!

You know, of course, that streams do not flow uphill. Why, then, does the Mississippi River flow away from the center of the earth? Because the earth is rotating! In doing so, it tends to move water, air, and other objects toward the equator. This force of the earth's rotation is enough to overcome the uphill grade from the north pole to the equator. What would happen, though, if rotation should cease? The rivers that now flow south to the Gulf of Mexico would flow rapidly north. What we now call a level surface would not be level any more, but would be tilted rather sharply upward toward the south. So *sea level* is a relative thing—a term describing the slope required to keep an object from rolling in spite of the earth's rotation.

Up and *down* are also relative terms and should be so indicated when talking about the earth and its relation to other bodies. It might be a good idea to mount a globe upside-down occasionally so that pupils do not get the idea that there is only one way to show the earth.

Children may think of the earth as being stationary, and the sun moving around it. And why not? Can't we *see* the sun move? This relative motion of the earth and the sun is a difficult one to teach to children. Even we adults may say that the earth rotates, and no doubt most of us still think of the ground beneath our feet as being a stationary platform.

Children can get the idea and the feeling of rotation, however, if when facing the south they lean slowly in their chairs to the *left*. Likewise, if they face north, they

can slowly lean to the *right*. This is the direction in which they are really turning. Two simple activities will help to show this. At night, when the stars are bright, set up a camera on a tripod and point it toward the north star. Open the lens wide (the smallest "f" number on the front of the camera). Set the shutter speed to "T" for a time exposure. Press the shutter release and leave the camera undisturbed for about a half hour or more. Return to the camera and trip the shutter once more. It will close at the second press of the shutter release button. If your camera has no "T" setting, but has a "B" setting, meaning "bulb", the shutter will stay open only as long as you hold down the shutter release. On this type of camera, the shutter release can be taped down with adhesive tape or held with a sturdy rubber band. Nearly all cameras can be arranged to take a time exposure of the stars.

The developed film, when printed, will show a picture like that on page 6. This picture shows that either the stars are all revolving about one point in the sky (a point near Polaris, the north star), or that the earth is rotating on an axis that is directed toward Polaris. Such a picture of the star trails does *not* by itself prove that the earth is rotating. It only shows that one or the other is happening. It took astronomers hundreds of years and much more evidence before they decided that it was the earth, not the stars, that was turning.

Another activity that is a "proof" that the earth rotates makes use of a pendulum known as *Foucault's pendulum*. A small heavy weight, a stick about 2 feet long, a string and an empty wastebasket may help you understand the principle of Foucault's pendulum. Place the stick across the top of the wastebasket. Suspend the heavy weight from the center of the stick so that it just clears the bottom. Set the weight swinging, and rotate the wastebasket. Does the weight (ball) rotate with the wastebasket, or does it tend to keep swinging in the same path in which it was started? Setting the wastebasket on a piano stool or phonograph turntable may allow you to turn it without jiggling. Can

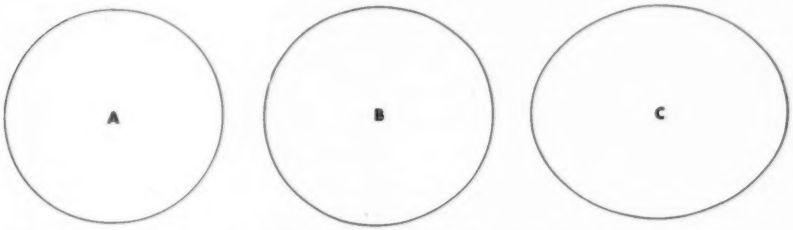
The plane of the pendulum shows little change as the wastebasket is rotated on the stool

turn to the right here in the northern hemisphere, how would it act in the southern hemisphere? (To answer this, put a chalk mark on a globe to show its direction of rotation, then turn the globe upside down. Hold a small pendulum over the south pole while you rotate the globe.)

Another bit of evidence for the rotation of the earth lies in the manner in which large air masses and water masses circulate. Imagine that the mountains of the earth are smoothed off, and that a giant ball rests on the earth at your feet. If you live in the United States you are moving from 700 to 800 miles per hour eastward as the earth rotates. The ball would be moving at the same speed. Now suppose you gave the ball a push toward the south. The ball would tend to maintain its 700 mile-an-hour speed eastward, but as it rolled south it would pass over earth that is moving faster and faster. Remember that while you are going about 700 to 800 miles per hour, a point on the equator is moving eastward about 1000 miles per hour. To someone standing at the equator and watching the ball roll toward him, it would seem to be going toward the west instead of coming straight south. Can you picture what would happen to a ball rolled north instead of south?

In the northern hemisphere, any object that moves across the face of earth tends to be deflected to the *right*. An ocean current moving south tends to be swung to the west. An air current moving north tends to be swung to the east. Because of gravity and the earth's rotation, one moving east tends to be deflected toward the south. This de*flective force* is largely responsible for the great circulation in the North Atlantic Ocean, the North Pacific Ocean, the lows and highs that produce our weather as they move across the land, and the horizontally-curved trajectory of missiles as they cross great spans of the earth's surface.

Just as objects are deflected to the right in the northern hemisphere, they are deflected to the *left* in the southern hemisphere. A high pressure system in the north rotates clockwise, but in the southern hemisphere it rotates counter-clockwise.



All three are ellipses, but A is the true shape of the earth's orbit

When Byron burned in two the thread holding back the pendulum, it started swinging

you see that the ball tends to keep swinging in the same plane in which it was started, even though the wastebasket is rotated?

Now suspend a very heavy weight from the ceiling of the classroom, or from the ceiling over a stair well of the school. Perhaps the janitor can help you assemble the apparatus like that shown on this page. For a pendulum you can use a #2 can filled with sand, or the iron shot from the high-school track team. The pendulum should just clear the floor when it swings.

Bring the pendulum about 3 feet back to one side and tie it there with strong thread. When it is motionless, burn the thread in two with a match. Freed, the pendulum will start to swing back and forth. Without touching the pendulum as it swings, try to mark its path on the floor with a piece of chalk or a string laid on the floor beneath the pendulum. As it swings, observe whether the path of the pendulum moves away from the line marking its original path. What do you notice? Can you see that the pendulum's path seems to be rotating to the *right?* This means either that the pendulum is rotating to the right, or that the floor beneath the pendulum is turning to the left. By using the wastebasket first, to show the analogy, it will be seen that it is really the building (the wastebasket) that is turning, and we with it. If Foucault's pendulum were swinging above either the north or the south pole, its path of swinging would make one complete turn in 24 hours. If the pendulum seems to

A staple and a bent nail make a low-friction support for a Foucault pendulum

mer as far away as 94½ million miles. Some persons think that these figures should be reversed, but actually *we are farther from the sun in summer than we are in winter.* It is the inclination of the earth's axis that makes the difference in our seasons, not our distance from the sun.

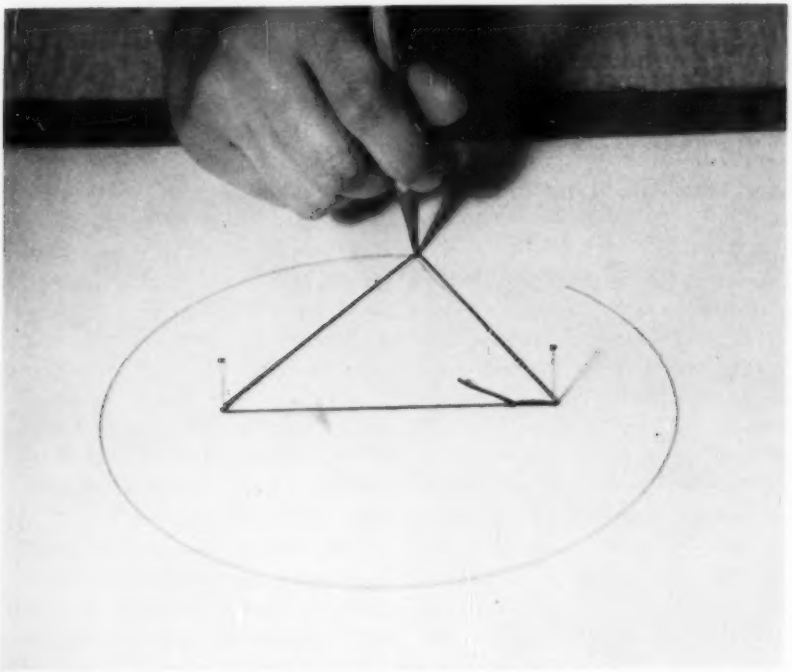
A simple activity will help you understand the true nature of the earth's path about the sun. You will need a sheet of paper, a piece of heavy cardboard about 12″ square, two pins, a piece of thread or string about 12″ long, and a pencil. Tie the string into a loop that when flat measures about 5″ long. Fasten the sheet of white paper to the cardboard. Near its center stick the two pins about 2″ apart. Place the loop of thread over the pins as shown. Now put the point of the pencil against the loop of string and, keeping the string taut, draw a line using the string as a guide. The finished curve should look like that on page 10. This is a true *ellipse*. Each pin represents a *focus* of the ellipse.

The earth's orbit is an ellipse, and the sun is at one focus of this ellipse. However, the shape of the ellipse is quite different from the one that you just drew. To see what the path of the earth really looks like, re-draw the ellipse, placing the pins 1/8″ apart, and using the same loop of thread. Can you tell this from a circle? Of course not! The orbit of the earth is far more like a circle than it is egg-shaped. Yet most of our books consistently exaggerate the earth's orbit until we have come to think of it as a noticeable ellipse.

The inclination of the axis

The seasons are caused mainly by the inclination of the earth's axis—an inclination of 23½° from the plane of the earth's orbit. If the axis of the earth were vertical to the plane of its orbit, then the only seasonal change would be due to our changing distance from the sun. However, the axis is inclined enough that for a part of the year our northern hemisphere is inclined toward the sun, and for a part of the year it is inclined away from the sun. The diagram below will help you see this. If the sun could be shown on this scale it would be 900 feet away! When you show such diagrams to children, never forget to emphasize that the distances have been exaggerated. Otherwise they,

On opposite sides of the sun the seasons are reversed, but the inclination of the earth is unchanged. (On this scale the sun would be 900 feet from the earth.)



Two pins, a loop of thread and a pencil are all that is needed to draw an ellipse

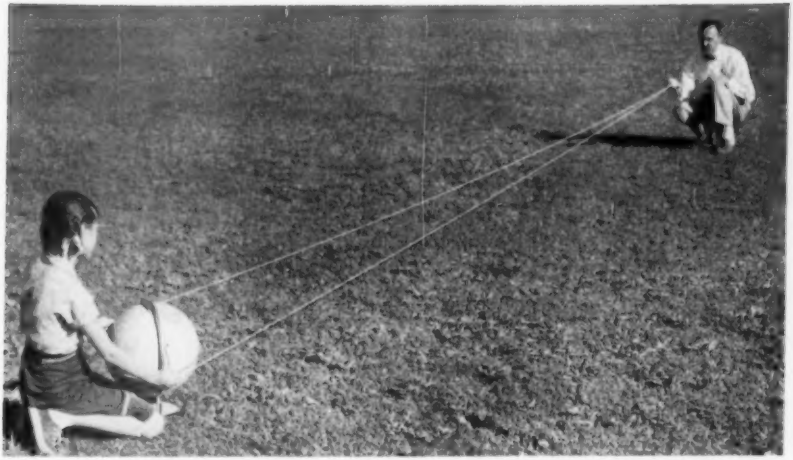
In the north a low rotates counterclockwise, but in the southern hemisphere it rotates clockwise. If our earth were stationary, none of these movements would take place. The deflective force is another evidence that we, not the sun, are moving.

The shape of the earth itself presents another bit of evidence that we are rotating. The slight flattening at the poles may be the result of bulging at the equator when the earth was more fluid than it is now. It would be difficult for scientists to explain the difference in equatorial and polar diameters in any other way.

The orbit of earth

On page 9 are three diagrams, one of which represents to scale the orbit of earth around the sun. Which do you think is most nearly correct? Which of the three do you see most commonly pictured in books? Which of the three would your pupils choose? Aren't you surprised to learn that "A" is the correct diagram?

The average distance from earth to the sun is 93,000,000 miles. This varies from summer to winter, however. In winter in the northern hemisphere we come as close as 91½ million miles, and in our sum-



The angle of the moon (tennis ball) as seen from opposite sides of the earth helps to determine its distance from the earth

would be about 16½° south of the zenith (40 − 23½°). This means that when summer begins where you live, the sun at mid-day will be about 5/6 of the way up in the sky and this is the highest it will ever be where you live. The next day it will be a little lower, and the next still lower, until at noon on December 21st it will be overhead at the Tropic of Capricorn (23½°S.). This is 63½° away from where you live (40 + 23½), so the sun will be 63½° away from the zenith, or only 26½° from the horizon.

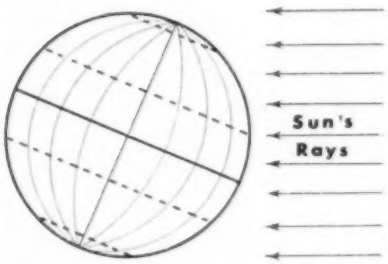
Just as the Tropics owe their significance to the position of the sun on the longest day of the year in the northern and in the southern hemisphere, the Arctic and Antarctic Circles are determined by the sun's position in the sky on those same days. Suppose it is June 21st, (or December 21st) and the sun is overhead at the Tropic of Cancer (or the Tropic of Capricorn). The sun's rays strike the earth at right angles at the Tropic. But they are *tangent* to the earth near the poles. The latitudes where the sun's rays are tangent to the surface of the earth are called the Arctic and the Antarctic Circles. The diagram on page 12 will help you to see this. Can you see from the diagram that as the earth rotates once in this position, there will be sunlight for 24 hours inside the Arctic Circle, but there will be darkness for 24 hours inside the Antarctic Circle? This is the reason for the names of the "Land of the Midnight Sun."

These relationships of the earth's movement around the sun to the seasons, the length of the day, the height of the sun in the sky, and the

too, will grow up with a misconception about our relation to the sun.

About June 21st, the north pole of the earth is inclined towards the sun. At this time the sun's rays strike more of the northern hemisphere than of the southern. About December 21st, the north pole of the earth is inclined away from the sun, and the southern hemisphere receives more of the sun's light and heat than does the northern. Throughout the year the earth's axis remains inclined *in the same direction*, always pointing toward the north star, Polaris. The reason that it seems to point toward a single spot in the sky is that Polaris is so far away (about 300,000,000-000,000 miles!) that the earth's little orbit is a mere speck in the distance. If the stars were only a few million miles away, then the earth's axis would not seem to point to the same place throughout the year.

When, in its orbit about the sun, the northern hemisphere of the earth is inclined as far toward the sun as it ever goes, that is the *beginning* of summer for us (the *beginning* of winter for people in the southern hemisphere). Because the inclination of the earth is 23½°, the sun appears to be at the *zenith* (directly overhead) 23½° north of the equator. The line on a globe that indicates this latitude is the *Tropic of Cancer*. This is the farthest north that the sun is ever seen directly overhead. Only between the Tropic of Cancer and the Tropic of Capricorn does the sun ever shine from directly overhead. Yet a recent book by a well-known elementary science authority says "...in summer, when the sun is straight overhead and shines straight down..." We must be careful not to give children the wrong impression about what the sun does. Nowhere in the United States does the sun ever shine straight down! No point in the United States is south of the Tropic of Cancer! From 23½° N. to 23½° S. (between the Tropics) is the only place where this can happen.



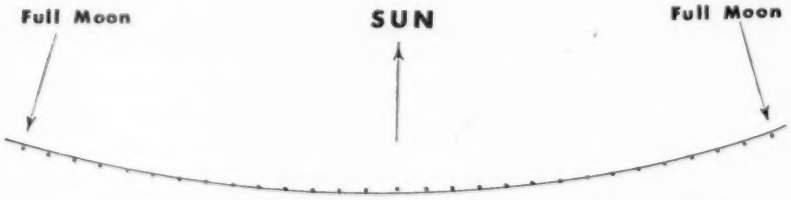
On June 21st where are the sun's rays tangent to the earth? at right angles? (On this scale the sun would be 1500 feet away)

One activity you can do with a class is to locate your city or town on a map, determine its latitude, then find out how far up in the sky the sun will appear at noon on June 21st. Suppose, for example, that you live at a latitude of 40° N. (Philadelphia, Denver, Madrid and Peiping are at this latitude). On June 21st the sun will be at the zenith at the Tropic of Cancer (23½° N.). From where you are, however, it

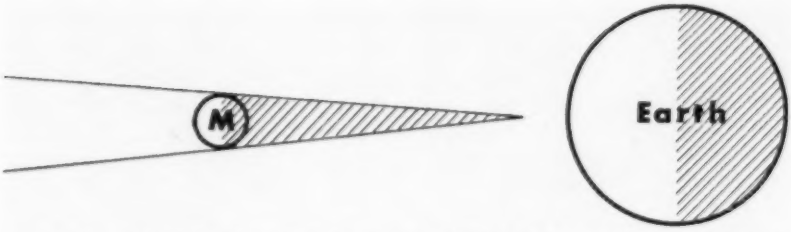
when they think you have the tennis ball "moon" at the proper distance from the globe "earth". Hold the ball at a distance of 1 foot, then 2 feet, then 3 feet from the earth, and so on. Keep a record of the children's reactions. Now put down what *you* think represents the distance from the earth to the moon.

The distance between the moon and the earth is about 238,000 miles. This, like the earth's distance from the sun, is not constant, but varies from 222,000 to 253,000 miles. If the globe in your room is 1 foot in diameter, *on that scale* 1 foot represents nearly 8000 miles. The moon's distance of 238,000 miles is represented by nearly *30 feet*. Suppose you fasten two strings to a tennis ball as shown on page 13. Ask a child to take the tennis ball (the moon) out to its proper distance while you hold a string at either side of the earth as shown. The strings can now represent the lines of sight of observers on opposite sides of the earth. Can you see how it is possible to compute the distance to the moon, knowing the angle of the line of sight, and the distance between the observers? This process is called *triangulation*, and was used many years ago to find the distance to the moon. On this same scale, the nearest star would be nearly 14,000 miles away. You can see how strings to such a body would be so nearly parallel as to be impossible of measurement. Distances of this magnitude are not computed by triangulation, but by other methods.

If the moon revolved about the earth in the same plane as the earth's orbit there would be an eclipse every month. The moon's orbit is inclined about 5° to that of the earth, however, so that the sun, moon and earth fall in a single straight line only occasionally. When this happens, an eclipse occurs. Your books show diagrams of this so it will not be repeated here. Total eclipses are not so common as they might seem, however, since the distance of the moon from the earth varies. This means that even when the sun, earth and moon are lined up, the moon may not be near enough to the earth to produce a total eclipse of the sun. Instead, it will produce a partial (annular) eclipse. The diagram on page 14

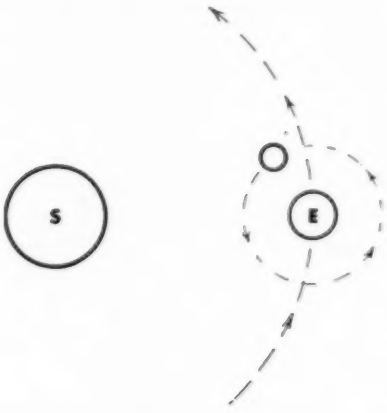


Drawn to scale, the daily positions of the moon as it circles the earth look like this. What is the shape of its orbit?



An annular eclipse results when the moon's shadow falls just short of the earth

position of the constellations are important in fixing our true position in the minds of children. In a space-conscious world, it is even more important that we realize our relation to the bodies about us if we are to appreciate the problems confronting those who plan to travel away from this planet. Our time, seasons, direction, speed, and position while on the earth will be quite different once we leave it.



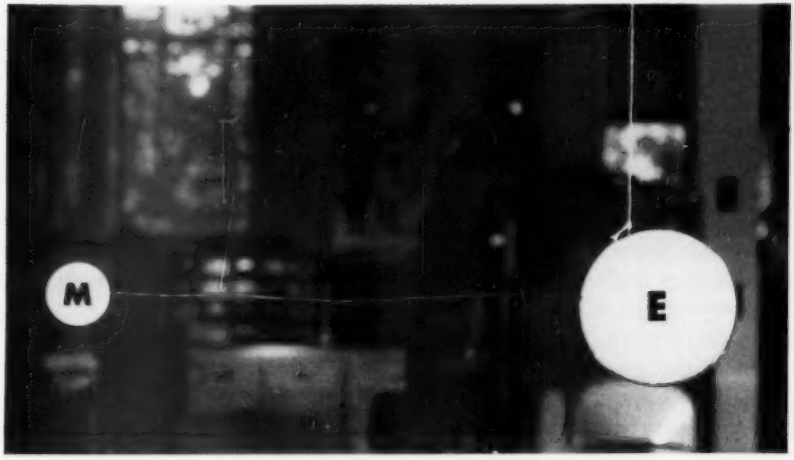
This exaggerated picture of the moon's orbit gives a false impression of its true path

Beyond the Earth

The moon

In order to get a true picture of our relationship to the moon, its size and distance should first be examined as they really are. Almost no book shows the size and distance of the earth and moon to the same scale. Most books in your own science series will show the earth and its moon on a single page—both large and close together. Let's see what the real story is, however. If the earth were the size of the globe in your room (about 1 foot in diameter), how big would the moon be? The earth, we know, is about 7900 miles in diameter. The moon is about 2000 miles in diameter, or about ¼ that of the earth. If the earth is represented by a globe 1 foot in diameter, then the moon would be about 3 inches in diameter, or about the size of a tennis ball.

It is interesting to compare the scaled distance to the moon with what children imagine it to be. Before actually demonstrating the scale model of the moon and earth ask your pupils to raise their hands



Earth and moon revolve around a point that is not at the center of the earth

You can make a model of the earth and the moon to show how they revolve about each other by fastening a rubber ball and a ping-pong ball to opposite ends of a wire as shown, and then finding the point at which these two balls balance. Fasten a thread or a string to the system at this balance point, and set the two balls to revolving about each other. This is the manner in which the earth and moon revolve about each other. Of course, the scale of your model will be exaggerated because of the weight of the wire connecting the two balls, but the principle is clearly illustrated. In its travels about the earth, the moon presents some other interesting relationships. If the moon remained facing the same direction in space at all times, we would see all of it as it revolved about us. If one side of the moon always faced a particular star, for example, we would in the course of a single year see the entire surface of the moon. This is not the case, however. The moon rotates once on its axis each time it revolves about the earth. One side always faces the earth. We have never seen the other side of the moon, and we won't see it until we can land on it and inspect the other side. It is because one side is always turned away from the earth that some scientists have suggested rocketing atomic wastes to the moon and landing them on the side away from us. In that way the harmful radiations would be lost to space and would not be a threat to the people of the earth.

Tides

The pull of the earth and the moon on each other are responsible for the tides that occur both in the

may show you why. Remember that distances in this diagram, like those in your books, are *exaggerated!* They must be in order to get the objects on a single page. To get the true picture, the same scale for size and distance must be used.

Books often show the moon's path around the earth to be something like that in the diagram on page 14. A pupil looking at this diagram might think that the moon makes loops as it revolves about the earth. On the scale that the moon is usually drawn, it would probably make moon loops. If the size and distance are drawn to the same scale, however, then the moon's path through space is not a series of loops, but rather a sinuous curve. In fact, the curve that it makes is always concave toward the sun! The diagram on page 15, and the following activity, may help to show you why this is true.

Using a string 4 feet long as a radius of the earth's path about the sun, make an arc about 2 feet long. This arc represents the path of the earth in one month (from full moon to full moon, or from new moon to new moon). On this scale, the moon would be 1/8 inch from the earth. Make a dot 1/8 inch from one end of the arc, on the side away from its center. This represents the moon's position at full moon. At the other end of the arc make another dot in a similar position. This represents the next full moon. In the middle of the arc, make a dot 1/8 inch on the side toward the center. This represents the new moon. Can you find the position of the moon at the end of a week? at the end of 3 weeks? at the end of each day during the month? Now you can see *to scale* what the orbit of the moon really looks like. How does it compare with what your textbooks show? By sighting at a low angle along the orbit that you have drawn, can you see that the moon's path is always concave towards the sun?

From what you have drawn, you can see that the moon does not make a series of loops as it orbits about the earth. The earth's orbit is too large for that. Instead, the moon's path is nearly a circle—a circle with a bit of a wobble in it.

Added to this movement of the moon about the earth are several other motions. The moon and the earth together act as a "system" in which the two bodies revolve about each other. The moon is only about 1/80th as "heavy" as the earth, so when it and the earth revolve about each other, it is something like a tiny person on one end of a teeter-totter, and another person 80 times as heavy trying to balance him. Can you see that the heavy person might have to sit so that part of him extends beyond the support of the teeter-totter in order to balance a small person? The earth is so heavy compared to the moon, that the balance point of the two, or the common center of revolution is inside the earth! The diagram on page 17 will help to show this.

water and in the air. The ocean tides are more regular and perhaps of more immediate importance to us because they affect shipping operations. Tides occur when the moon, earth and sun are nearly in line, and they also occur when the sun, earth and moon form a right angle. Your books show these conditions and describe them as *spring tides* and *neap tides*, respectively. The moon attracts the fluids (mostly water) on the side of the earth nearest it. This water tends to pile up under the attraction of the moon in what we call a tide. On the opposite side of the earth there is a piling up of water that is more difficult to explain. Remember, however, that the earth is revolving about a point just as the moon is. This point is on the side of the earth toward the moon, but is beneath the surface of the earth. Imagine that the earth alone were spinning about this point—a sort of lop-sided earth. Can you see how the water on the side opposite this point might be whirled into a pile? Now put the moon back in place. Can you see that the moon pulls the water up on one side, but that the revolution of the earth about the earth-moon center helps to pile up the water on the opposite side? The same holds to a lesser extent for neap tides.

Children may wonder why tides do not occur just at the moment the moon is overhead. It takes time for the water to flow over the earth's surface. Imagine that in an instant the moon appears overhead, and that the waters of the region begin to converge on that spot. But as soon as the waters begin to move, the moon also moves to another place a little west of where it was. Now the water begins to converge on that spot. Again the moon moves, and so the water never quite "catches up" with the moon. This lag, together with the irregular shorelines of the continents, make the tides appear in different places at different times—but always with a regularity that can be predicted and published in tables for the use of seamen.

The contour of the shoreline plays a big part in the size and the time of the tides. Along the coast of New Jersey and Long Island, the spring tide is about 6 feet. Several hundred miles to the north, however, in the Bay of Fundy, the tides rise as much as 40 feet. There has been much speculation about the possibility of damming a place like the Bay of Fundy, letting the dammed water escape through sluice gates where giant water wheels can be made to turn and generate electrical power. The tides represent perhaps the greatest source of power known to man if an effective way to harness their energy can be found.

Rockets and space travel

The gravitational pull of the earth and moon have another relation to us that is becoming increasingly important. In our frantic attempts to conquer space, we have

set our sights on the moon as the nearest natural body to which we can some day travel by rocket. In the model of the earth and moon that was described on page 15, you learned the true relation between size and distance. At the time this Leaflet is being written, the highest point reached by any artificial satellite is less than half the earth's diameter away. The moon's distance from us is 75 times that far. How, then, are we going to get a rocket to the moon if the best we have done so far is to send one up about 3000 miles? The answer to that lies in the gravitational fields of both the earth and the moon.

As a rocket leaves the earth, the pull of the earth on it becomes less and less as the rocket roars out into space. If you imagine a line between the earth and the moon, somewhere along that line, nearer the moon than the earth, the gravitational pull of both the earth and the moon on an object are just about equal. An object placed on the moon side of that point would be drawn to the moon. An object placed on the earth side of that point would be drawn to the earth. So a rocket need be sent only to this "point of no return" in order to get it to the moon. The moon's gravity will pull it the rest of the way.

The return trip of the rocket to earth is, in some ways, less of a problem. The earth's gravitational field reaches far closer to the moon than does the moon's to earth. So it will be necessary to fire an earth-rocket only a few thousand miles away from the moon to reach a point where the rocket will drift to earth under the earth's gravitational pull.

The problem of rocket travel is not so much concerned with getting the rocket into space, as with guiding the rocket after it leaves the earth's surface. Remember that the moon is constantly circling the earth. A rocket fired at the moon, and traveling in the direction in which it was fired, would miss the moon by a wide margin and perhaps continue to drift out into interplanetary space until "captured" in another planet's gravitational field. To reach the moon, a rocket must be fired toward the point where the moon will be when the rocket has traveled the required distance. This requires precise calculations of the speed and direction of the rocket, and of the speed and direction of the moon.

For a rocket to arrive at a point where the moon's gravity will pull it the rest of the way, it must reach a speed called the *velocity of escape*. The velocity needed to escape from the earth is about 25,000 miles per hour or 7 miles per second. Long ago some gas molecules moved this fast and escaped into space. Our atmosphere has left only those molecules that move slower than 7 miles per second. At a speed less than this velocity of escape, a rocket will merely circle the earth in an orbit, as do the artificial satellites of the

United States and Russia, and eventually fall back to earth.

A simple activity will serve to show what makes a rocket orbit when a particular speed is obtained. Roll a small sponge rubber ball across a table top and let the ball fall to the floor. Mark the place where the ball strikes the floor. Now roll the ball a little faster and mark the place where it strikes the floor. Repeat this activity, each time increasing the speed with which the ball rolls across the table. Can you see how it would be possible, given enough speed, for the ball to fall toward the ground in a curve that is parallel to the earth's surface?

When a rocket is sent into the sky, the job of the first (and most powerful) stage is to propel it through most of the earth's atmosphere where friction and gravity are greatest. The second stage accelerates the rocket still more and gradually raises it to the desired altitude. The third stage speeds up the rocket just enough so that its fall to the earth nearly equals the rate at which the earth's surface curves away from it. The result is that the satellite keeps circling the earth, "trying" to fall back to earth, but constantly thwarted in its attempts, since the surface of the earth curves away from it as fast as the satellite drops toward the earth. The satellite is in orbit!

Air: space barrier

If the speed of a satellite decreases so that it drops faster than the earth's surface curves away from it, then it comes closer and closer to the earth, until it finally enters air so dense that the friction of the air usually melts it or otherwise damages it. Up to now all the artificial satellites that have fallen from their orbits have disintegrated in the atmosphere. The presence of air on the earth, while a great advantage to us who live at its bottom, is a great barrier to objects that try to penetrate it either from the surface of the earth, or from outer space. For space travelers it presents as many problems as the distance between the bodies themselves.

The diagram on page 21 shows the relation of the air ocean to the surface of the earth. Many scientists consider that the air extends up to about 500 miles above the earth's surface, although in reality, it probably extends considerably higher. As the altitude increases, however, the air gets so "thin" that after a time its presence is nearly immeasurable. Even at altitudes of 500 miles there is enough air so that an artificial satellite cannot orbit forever. Each revolution around the parent earth takes a tiny bit longer —perhaps only a fraction of a second—so that the satellite slowly loses altitude. As it nears the earth it gets into "heavier" and "heavier" air. This slows it down still more. In its final revolutions about the earth it falls rapidly toward the earth's surface.

About one-half of all the air above us lies in the first 3½ miles

This curve represents the surface of the earth. More than half the atmosphere lies within the thickness of the line!

above sea level. In the first 5 miles above sea level most of our weather occurs. In the first 8 miles above sea level nearly all our aircraft flight takes place. Mt. Everest, the highest point on the earth's surface, projects into this atmosphere to a height of 5½ miles. The highest that man has ever been (summer of 1958) is about 17 miles. The highest that balloons have been sent is about 26 miles. The highest that a jet has flown is about 15 miles. Rockets, however, have been sent to heights exceeding 500 miles, and plans are being completed for sending them to the moon. Try scaling these heights off on a globe to see how they compare with the size of the earth. On a globe 12″ in diameter, half of the atmosphere would be just a little more than the thickness of a human hair! Mount Everest would project the thickness of three hairs! The thickness of a grocery string would represent the highest balloon. The latest artificial satellite would be circling the earth at a distance of a little less than 3 inches. Comparing this with the scale model of the earth and moon described on page 15, you can see that any satellite that reaches the moon has a long way to go.

On this scale the atmosphere seems pitifully thin and unprotective. Yet it is this thin skin of air around our earth that protects us from such things as harmful ultra-violet rays, meteors, and cosmic rays from the sun. Rockets that have reached the upper levels of the atmosphere, where there is almost no air surrounding them, report a great increase in the ultra-violet rays, a great increase in the meteors that go zipping by at fantastic speed, and a deadly increase in the cosmic radiation—radiation that future space travelers must be shielded from if they are to be safe.

Incoming solar radiation penetrates the atmosphere and is absorbed or reflected by the earth beneath. The radiation that is absorbed is changed to heat. Heat energy is long-wave radiation that cannot penetrate the atmosphere so easily as the shorter light waves can. So the heat is trapped beneath the air blanket above us, much the same way heat is trapped by the glass of a greenhouse. A simple activity will show how this works. Place an inexpensive thermometer inside a glass jar with some soil on the bottom. Screw the cover on and place it in the sunlight. After a few minutes examine the thermometer by looking through the jar. What has happened to the temperature? Compare it with the temperature

the globe or an orange or yellow balloon in the center and let each child pace off the distance to his particular planet. Once at the proper distance from the sun, the child can circle the sun as his particular planet does. This activity helps to develop an understanding about the relationships of other planets to us, and to the sun.

Mercury, for example, circles the sun about three times every year. A child circling the sun with his model planet, Mercury, would always be fairly close to the sun. Mercury is never visible when an observer on earth is turned away from the sun (when it is nighttime). If the sun were very, very bright it would be difficult to see such a small body as Mercury that shines only by reflected light from the sun. It can be seen best when an observer on the earth is just hidden from the brilliant sun (in early morning or early evening). It can also be seen through a telescope with a darkened eyepiece when Mercury crosses between us and the sun. At this time it shows as only a dark dot moving slowly across the sun.

The slow rotation of Mercury, together with its nearness to the sun, makes it a planet of temperature extremes. On the daylight side (daylight on Mercury lasts about 40 of our days) the "noon" temperature may reach hundreds of degrees Fahrenheit. At midnight (44 earth-days later) the temperature may

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Distance from sun in millions of miles	36	67	93	141	483	886	1783	2794	3670
Diameter in miles	3,100	7,700	7,900	4,200	88,700	74,200	32,400	31,000	(8000)
Distance from sun in feet (if sun is 4 foot in diameter)	50	93	130	196	672	1,270	2,480	3,890	5,120
Approximate size in inches (if sun is 1 foot in diameter)	1/16	1/8	1/8	1/16	1 1/4	1 1/8	1/2	1/2	(1/8)
Weight compared to earth	0.04	0.82	1.00	0.11	318.0	95.0	14.7	17.2	(0.93)
Number of moons	0	0	1	2	12	9	5	2	(0)
Period of revolution in years	0.32	0.62	1.00	1.9	12	29	84	165	248
Period of rotation in hours	88	(?)	24	24.5	9.9	10.0	10.7	15.7	(?)

outside the jar. Can you see that the sun's rays coming into the jar are trapped so that the temperature rises considerably beyond that of the surrounding air? The same thing happens, of course, in an auto with the windows closed when it stands in the sunlight. Can you see why you should not keep a terrarium in direct sunlight?

At one time scientists thought that far up in the atmosphere it was extremely cold. They knew from balloon "soundings" that the temperature of the upper air was about −50°C., but they could only guess at the temperature higher than that. Recent observations with modern instruments show that the temperature is hundreds of degrees above zero high in the atmosphere. This heat is an additional problem for space travelers and rockets that we send out toward the moon and other planets.

Beyond the Moon

Once the moon is reached by rocket, the next step into space will be the neighboring planets. Beyond the moon lies an interesting array of planets, many with their own satellites just as we have our moon. As with diagrams of the earth, sun and moon, most textbooks include diagrams of the planets with their size to one scale and the distances between them to an entirely different scale. This is confusing to children, and leads to entirely false impressions of the true relationship of size and distance. You as a teacher can easily remedy the situation with a simple activity.

Models of the solar system bodies are easy to make, and give an idea of what our solar system is—mostly space. Using a classroom globe as the sun (it can be covered with aluminum foil to hide the surface colors), the planets can be fashioned from clay or bits of aluminum foil wrapped around the heads of pins stuck into corks. If a 1-foot globe in your classroom represents the sun, 1 foot represents 860,000 miles. Since the earth is only 8000 miles in diameter compared to the sun's 860,000 miles, on this scale the earth's diameter would be only $\frac{8{,}000}{860{,}000}$ of a foot, or about 1/108 of a foot. This is about 1/8". How different this is from the diagrams in your classroom texts!

If the sun is represented by the globe above, and the earth by a 1/8-inch ball, the scaled distance to the sun (93,000,000 miles away) can be determined. Each 860,000 miles is represented by 1 foot. So 93,000,000 miles is represented by $\frac{93{,}000{,}000}{860{,}000}$ feet. This means that the earth is 130 feet from the sun on the scale that we are using. The table opposite will help you find the distances of the other planets and then model them to scale:

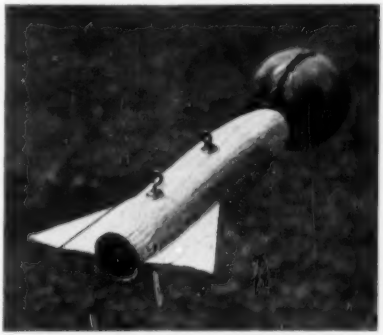
Each child in the room can model one or more of these planets. To model their distances to scale, take the class out to the playground. Set

atmosphere on Mars is thin, and may present a serious limitation to life. The planet is smaller than the earth, and has a gravitational pull only about 4/10 that of the earth. This means that certain gases such as hydrogen and helium may have escaped long ago. The velocity of escape on Mars is only 3 miles per second compared with about 7 miles per second on the earth. So a rocket to Mars would need less push to leave Mars than it needs to leave the earth.

Because Mars orbits outside the earth's path, it can sometimes be seen in the nighttime sky. It takes Mars nearly 2 years to travel around the sun, but it takes us only 1 year. So sometimes Mars is on one side of the sun while we are on the other. Then Mars is difficult to see because it lies in the direction of the sun. When Mars is on the same side of the sun as we are, it is bright—occasionally brighter than Jupiter. When Mars is in that part of its orbit that is nearest the sun, and we are in that part of our orbit that is farthest from the sun, the two planets are close together. In 1956 we were very close together and Mars was easy to see. We will be close together again in November, 1958 and again in December, 1960. We will make a very close approach in 1971.

Beyond Mars, there is a great "gap" between the planets. In this gap are many small planet-like bodies with orbits of various shapes, most of which are very elliptical. These *asteroids* cannot be seen with the naked eye, since the largest of them is less than 500 miles in diameter, and most of them are only a fraction of this. The orbits of some swing far out beyond Jupiter, then in as far as Venus. Most of them orbit between Mars and Jupiter. About 1500 of these asteroids or planetoids have had their orbits determined, although thousands have been discovered.

The largest of the planets, *Jupiter,* is also a very bright object in the night sky. Even at a distance of nearly a half billion miles, its immense size makes it visible. The great distance of Jupiter from the sun accounts for its low temperature of about −250°F. The rapid rotation (about 25 times as fast as the earth) makes it bulge at the equator. The brightness of Jupiter varies because of its path about the sun. When Jupiter is on the same side of the sun as the earth, it is only about



This simple wooden rocket with cardboard fins is powered by a CO_2 cartridge from the drug store. A rubber ball stops the rocket

have fallen to a hundred or more degrees below zero. Mercury, for this reason, must be a desolate planet and completely devoid of any life.

Venus is a mystery planet. It is the closest to us of any of the planets, but its surface is constantly hidden by a cloud cover that scientists believe is composed of an extremely high percentage of carbon dioxide—perhaps 10,000 times as much as is present in our atmosphere. Carbon dioxide in the air acts like the glass in a greenhouse. It permits short-wave radiation (sunlight) to pass through and strike the surface of the planet. There the short-wave radiation is absorbed and becomes heat (long-wave radiation). These long waves do not penetrate carbon dioxide easily, so they remain trapped much as sunlight remains trapped inside a greenhouse, or inside a closed car. For this reason, the surface of Venus may be very hot—too hot to permit life there.

When Venus is on the same side of the sun as we are, it appears as a thin crescent. The crescent can be seen only with a telescope or a strong binocular. To the naked eye it looks like a bright star. When it is on the other side of the sun from us, however, it resembles a full moon. At that time we are 93 million miles from the sun and Venus is 67 million miles the other side of the sun. Even at that distance, the sunlight reflecting from its cloud cover makes it the brightest object in the sky outside of the sun and moon. It is brighter than Sirius or the largest planet Jupiter.

Like Mercury, Venus is between us and the sun, so it is never seen high in the sky at midnight. At midnight an observer on the earth would be looking out into space directly away from the sun, and away from Venus' orbit. For that reason, Venus is commonly called the "evening star" or the "morning star", depending upon its position in the sky.

The planet that has stirred the imagination of astronomers and fiction writers more than any others is *Mars*. It is not so near to us as Venus, but there are few or no clouds to obscure our observations of its surface. In 1877 an Italian astronomer, Schiaparelli, observed a series of many fine lines over the surface of Mars. He described these as "canali", meaning channels. His choice of the word "canali", and its translation into canals, has set many persons to wondering if these could have been made by any intelligent beings. Such is possible, but it is much more likely that another form of life such as primitive plant life exists on Mars. This reasoning is based on the color changes that can be observed on Mars as the seasons change. In addition, there is known to be a white polar cap at each pole. These white caps recede and advance with the change in seasons and are thought to be made of ice or snow, suggesting the presence of water on the planet. However, the

250 years to orbit, and its orbit is so elliptical that at times it approaches closer than Neptune. At its farthest, it is nearly 2 billion miles away from the sun. Obviously, our space journeys for some years to come are going to be confined to short trips well inside the orbits of these farthest planets!

Rockets: space machines

When objects such as planes and rockets move through the earth's atmosphere, they depend upon the air for their guidance. Fins, rudders, and ailerons all serve to push against the air and swerve the plane or the rocket in one direction or another. The rotating wings (propellers) of a helicopter need the air in order to supply "lift" to the plane. Out in space, however, things are quite different. There is no air for wings to support a plane. Propellers are useless for they depend upon air to give the plane its push. Rockets, however, do not depend upon air. In fact, they work better where there is no air.

Imagine a gun suspended motionless from a string. Suddenly the gun is fired. The bullet travels rapidly in one direction. The heavier gun "kicks", moving more slowly in the opposite direction. If the gun were fired automatically, the next bullet would "kick" the gun backward a little faster, and the next still faster.

In a rocket, high-speed gases are the "bullets." All gases have weight, and the faster the gases are fired from one end of the rocket, the faster the rocket recoils in the opposite direction. Air serves only to provide friction for the rocket and thus holds it back. As the rocket burns its fuel, it gets lighter and goes faster. If the rocket is made in sections, so that as the fuel in one tank is used up, the tank can be discarded, the weight of the rocket is even more reduced, and its speed increases. In multiple-stage rockets the first stage contains tremendous amounts of fuel for getting the rocket off the ground and through the lower layers of air. The next stage continues to accelerate the rocket, sending it into the upper, thin layers of the atmosphere. The final stage of the rocket boosts the speed of the nose to the amount needed to make the rocket orbit. The final stage must push the rocket parallel to the earth's surface, or the rocket might continue right out of the earth's gravitational field... to the moon! Perhaps by the time you get this Leaflet a rocket will have been sent to the moon.

Once a rocket is in outer space, fins are useless to change direction. Outside the atmosphere, smaller jets of gas must be used to change the direction of a missile. A gas jet pointed to the right could move the missle to the left. A powerful jet directed forward could act as a brake. All this complicates the machinery and the amount of fuel needed for a trip into space. As superior fuels are developed, and directional mechanisms simplified,

400 million miles from us. When it is opposite the sun from us it is about 600 million miles away from us. This makes Jupiter seem brighter some years than others.

If you look at Jupiter through a telescope or a binocular, you can often see four moons lying in a line across Jupiter. Sometimes one or more of the moons will disappear behind or in front of the planet. Actually, there are 12 known satellites of Jupiter. The other 8 are too small to be seen except with a large telescope.

Saturn is not quite so large as Jupiter, and is farther away (nearly 900 million miles). It is famous for its rings. These rings extend out from the planet nearly 85,000 miles to each side, so that they make a disc about 170,000 miles across. This is more than twice the diameter of the planet itself. The rings are only about 10 miles thick, however, so that in side-view, they seem to disappear altogether. In fact, when Galileo observed this planet in the 17th century, he thought the bright spots that touched the planet at either side (the rings) disappeared, then reappeared again some years later. He must have seen the rings from the side, then later from the front or the back. The rings are inclined like the earth's axis, so when Saturn revolves about the sun its rings are sometimes edgewise to us, and sometimes they face toward us. Saturn appears much brighter when its rings are toward us, than when they are edgewise to us.

Susie uses a spring-powered needle to puncture the end of the cartridge and start the rocket whooshing along the wire

Beyond Saturn lie the planets of *Uranus, Neptune,* and *Pluto,* of which only Uranus is visible to the naked eye. It is very faint—about as bright as the faintest stars. Neptune and Pluto were both predicted before they were seen. Each was "discovered" because of some irregular motions of Uranus that could be explained only by the presence of another planet farther out than Uranus. The discovery of Neptune helped to explain some of the strange movements of Uranus, but not all. There was still something else "out there" that astronomers searched to see. Finally, in 1930 it was spotted—the farthest of our planets, Pluto. It takes Pluto about

4. Let two children squat on roller skates, then push against each other. What happens? Let one child on skates roll a bowling ball across the floor. This is the principle of a rocket. The ball (gas) goes one way; the child (rocket) is pushed the other.

5. Measure the distance from the center of a teeter-totter to children of various weights balancing on it. Compare the distances that heavy and light children must sit to balance.

6. Hang some ping-pong balls on threads about the room. Arrange them so that they look like the big dipper when seen from one place, but like something else when viewed from another place. The constellations are not all in one flat plane!

For upper grades

1. Arrange a Foucault's pendulum as indicated on page 8. Keep a record of its path as it swings back and forth. What does this indicate about the movement of the floor beneath the pendulum?

2. Using two pins, a loop of thread, and a pencil, practice making ellipses of different eccentricities. (The eccentricity of an ellipse is the distance between pins divided by the longest dimension or axis of the ellipse.)

3. Draw to scale the orbits of the earth and Mars as described on page 11. Earth's foci (two pins) should be 1/8″ apart, and the loop of thread 5″ long when closed. Mars' two pins should be 1 1/4″ apart and the loop 7 1/2″ long when closed. Place the orbit of Mars over that of the earth, using one pin through a focus of each orbit. Rotate the orbit of Mars 1/3 of a turn around the pin. Can you tell from this model of the orbits at what time of year the two planets will be closest together?

4. Make a series of star-trail pictures that includes the planet Jupiter. Take a picture each week for several weeks, then compare the position of Jupiter against the background of stars. Has it moved? Which way? Its position may also be sketched at weekly intervals on a star chart as well as photographed.

the chances are better for sending controllable rockets into space.

Beyond the Solar System

Beyond the planets and our sun there is mostly s p a c e . . . ! The nearest star to our solar system is 26,000,000,000,000 miles away. At the escape velocity of the earth (7 miles per second) a rocket heading toward this star would not reach it until after 110,000 years. This is 20 times longer than from ancient Egyptian times to the present! Such distances are almost beyond comprehension. Miles are too small a unit to express them so the distance that light travels in one year *(a light year)* is used. One light year is equivalent to nearly 6,000,000,000,000 miles. The Leaflet, LET'S MEASURE, tells you more about astronomical distances. You can soon see, however, that travel beyond the solar system is at present a figment of the imagination. Fuels would get us into space, but once there and proceeding at a speed of even hundreds of miles per second, we would not live long enough to get where we wanted to go. In addition we could not carry sufficient food, water, and oxygen to make the trip. So for many years to come, man must be content to explore the immediate space around his earth, and only look at and listen to the things outside his own celestial family, the solar system.

Things To Do With Your Classes

Lower grades

1. Keep a record of the shape of the moon, and the date. Each day, cut out pieces of paper the shape of the moon and paste them on a calendar. Children will soon see the relation between dates and the phase of the moon.

2. Use a chalk line or a piece of string to outline the shadow of a flagpole or a stick in the ground. In a half-hour check the shadow again. Did it move, or did the string move? Does the sun or the stick move? (How can you tell?)

3. Lay a yardstick on a table. At each end place a straw, both of which point to the same object. Repeat, pointing to a more distant object. How does the angle of the straws change? What is the farthest apart the straws can get?

THE GOLDEN BOOK OF ASTRONOMY *by* ROSE WYLER AND GERALD AMES. *Simon and Schuster, Inc., New York. 1955. 96 pages.* In this remarkably complete book are explanations of day and night, the seasons, and eclipses, together with descriptive information on the planets, the sun, and the galaxies beyond the Milky Way. A section on rocket travel, its problems and promises, concludes the book. Intermediate.

EXPLORING THE MOON *by* ROY A. GALLANT. *Garden City Books, New York. 1955. 63 pages.* This large (9 x 12) beautifully illustrated book concerns the origin of our natural satellite and its surface features as well as its effects on our tides and its role in eclipses. More space is given to conjecture than to the known motions and character of the moon. Intermediate, Upper.

MAN-MADE SATELLITES *by* WILLIE LEY. *Simon and Schuster, Inc., New York. 1958. 44 pages.* This new book describes the construction, orbit, and possible uses of artificial satellites as a navigational aid, a space photographer, a weather observing station and a television antenna. It is a concise, attractive, informative book. Intermediate, Upper.

ORBIT *by* HY RUCHLIS. *Harper and Brothers, New York. 1958. 147 pages.* In this book about force and motion, gravity, tides, earth satellite orbits, and the moon's orbit are well described. Simple drawings and analogies to commonplace things are used to illustrate the principles involved. Upper.

PLANET EARTH *by* ROSE WYLER. *Henry Schuman, Inc., New York. 1952. 154 pages.* Beginning with a description of the solar system and how the earth compares with the other planets, the book describes the sun as a star and why it shines; the earth's relation to other heavenly bodies; the earth's movements; its surface features; and many other topics. A comprehensive text. Upper.

5. Construct a simple rocket that will glide along on a taut wire. A heavy cardboard mailing tube or a hollowed piece of wood will serve as the body. Load the rocket with a small CO_2 cylinder such as can be purchased at the drug store. At one end of the wire place a pillow or some other soft object to stop the rocket. Puncture the end of the CO_2 cylinder with a pin or a needle-sharp nail and a hammer, and it will swoosh down the wire at high speed. What happens to the CO_2 cylinder? Why?

6. Lay out the solar system to scale on the school playground. With the children (planets) in position, let them circle the sun at proportional speeds. Now let another child be a comet and come running through the solar system in a curved path that comes close to the sun. This should provide material for interesting discussions about space, matter and probability.

Some Helpful Pupil References

TRUE BOOK OF MOON, SUN, AND STARS *by* JOHN LEWELLEN. *Children's Press, Chicago. 1954. 48 pages.* About half of this book for beginning readers presents simple, interesting information about the moon. The latter sections deal with the sun, stars, the earth's rotation and revolution, and "shooting stars" that are not stars. Primary.

YOU AMONG THE STARS *by* HERMAN AND NINA SCHNEIDER. *William R. Scott, Inc., New York. 1951. Unpaged.* In this unique book, young readers look beyond their own home, city and state to the universe of which they, their home, and their country are parts, and become acquainted with many sky phenomena. The text is clear and simple, and touches upon subjects about which young children often are curious. Primary.

THE EARTH SATELLITE *by* JOHN LEWELLEN. *Alfred A. Knopf, Inc., New York. 1957. 59 pages.* One of the Highlights of the I.G.Y. was the launching of the first artificial satellite. Here, in simple text and illustration is a description of the problems involved in getting a satellite into orbit and keeping it there, and of the transmission of data back to earth. The satellite's movements rather than its construction is emphasized. Intermediate.

The CORNELL SCIENCE LEAFLET

Successor to the Cornell Rural School Leaflet, the CORNELL SCIENCE LEAFLET is a non-profit publication of the New York State College of Agriculture at Cornell University. It is intended to stimulate good science teaching in the elementary schools of our country. Formerly it was distributed free to the public schools of New York State, but rising publication costs and increasing demand have necessitated a charge for the Leaflet service.

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VERNE N. ROCKCASTLE
Editor

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